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The scallop fishery is of small moment in the United States beside the production for market of oysters and clams, and the statistics (for which I am chiefly responsible) are meager, and not later than 1881, though I doubt whether this year's figures would show much difference from the status of five years ago.

Briefly summarized, these show that about 250 men (and for a short season at New Suffolk, Long Island, about 470 women and children, according to Fred. Mather), are engaged in either catching or preparing scallops, using boats and apparatus worth perhaps $20,000.

The total product is from 70,000 to 75,000 gallons of the edible part, as marketed, worth at first hand from $25,000 to $30,000. About one-half of this comes from Peconic bay, and more than half the remainder from Greenwich, Long Island.

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SUPER-METAMORPHISM AND VULCANISM.[1]

BY THEO. B. COMSTOCK.

If it be true that metamorphism has converted Archæan sedimentary strata into the crystalline condition in which those beds now usually exist, there can be little doubt that some igneous rocks have had a similar origin. We can not detect the direct evidence of such previous condition in the thoroughly fused masses, but there is in many cases no real proof to the contrary, to say the least. Now, if these simple postulates be admitted, how can we consistently deny the possibility—nay, the probability—of the occurrence of all degrees of metamorphism from the simple baking to the melting effects? Geologists have commonly supposed that a well-defined zone of metamorphism has existed over the earth involving just so much of the sub-stratum of the crust, never passing the boundary set by the lowest member of the Palæozoic series. This view does not comport with the very gradual transitions observable in all other natural products, nor can it be reconciled with the numerous facts which go to prove that the great geologic agents of the past are active now as then, in kind if not in degree.

Really, then, it would be marvelous if extended study of geological history should not reveal fluctuations of the metamorphic zone, above and below the arbitrary stratigraphic boundary adopted in the early days of our young science.

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[1] Abstract of two papers read before Section E, A. A. A. S., Buffalo, 1886.

Without arguing this point further, I desire to present here some facts which seem to indicate that true Palæozoic strata have in one region (S. W. Colorado) become involved in the zone of metamorphism; that is to say, *super-metamorphism* has occurred. All along the Rocky Mountain chain to the northward the Silurian beds are recognizable, although I have seen them very much baked in portions of Northwestern Wyoming. The same succession of strata from top to bottom of the Palæozoic is discernible southward, as a rule, until we strike the great loop of the continental divide in the San Juan mining region, where the sedimentary formations skirt the base of the Quartzite mountains of Hayden's survey. Here the Carboniferous and the underlying Devonian are well represented, and insignificant remnants of supposed Silurian strata occur *in situ*. In some cases these last-mentioned rocks shade down gradually from the unmodified sediments to the completely metamorphosed layers, and occasionally the Devonian limestone is so intimately connected with the subjacent granite as to form a continuous block of the two rocks *welded* together into one mass. Beneath the granites is a vast formation of quartzite, and the whole section studied by itself and in connection with the succession of strata in the adjoining country, seems to me wholly inexplicable upon any other theory than that of super-metamorphism, involving a considerable thickness of the early Palæozoic beds, including nearly all of the Silurian formation.

This idea, although worked out independently by myself, was, I find, entertained some years ago by Dr. Endlich, who passed rapidly over a part of the region in 1874. The importance of the fact, if such it be, of this super-metamorphism appears very evident when we come to study the history of vulcanism in Colorado and Wyoming. From observations by the writer in the latter area, in 1873, there seems no doubt that very similar conditions have existed in that great focus of eruption, although the results have been there much obscured by the lava flows and less disclosed by subsequent erosion.

Referring to the preceding remarks on super-metamorphism, we may understand how, with a crust offering excessive resistance, the igneous fusion may be longer continued than in the case of a volcanic eruption like those of the early Tertiary in the West or the Hawaiian initial outflows, all of the andesitic type. Von Richthofen's series, as exemplified in the order of succession of the lavas of the Western United States is, in the rough, of such wide application that we must expect to discover more than a mere accidental cause. The occurrence of only one type of lava, as andesite, trachyte, rhyolite, or basalt, may be readily explained as due to the overcoming of the resistance to outflow at one or other stage of the process of fusion. So, in certain wide areas, it might be possible for all of Richthofen's types to be ejected from as many distinct orographic centers. But in Wyoming and Colorado two great districts have the old volcanic vents so related to each other, in the several flows, that one can not avoid the conclusion that each field has been the seat of one long-continued period of activity marked by successive epochs of eruption. Thirteen years of study in these regions have revealed many facts bearing upon these questions. Having elsewhere outlined a plausible theory of vulcanism,[1] based upon these and general information gleaned from the West Indies in merely traversing that region, together with the published accounts of leading authorities, I shall not here attempt a discussion of it, but confine myself to a simple statement of its main points.

In brief, then, it seems evident that the earliest volcanic outflows came out through lines of least resistance in the axes of folds in the strata. In cases where these lines coincide with the major folds and the lines of maximum tension, the outflow will be andesitic or basaltic, *i. e., basic.* If the tension be not sufficient to overcome the resistance, more acidic material will be formed at the top of the magma, under the folds, and this may burst forth as trachyte, or finally as rhyolite, provided that the resistance is not sooner overcome. Basalt comes last as the deep-seated, heavier portion of the magma, and in some cases this follows andesite without the intervening trachyte and rhyolite.

In the San Juan mining region and in the Yellowstone Park area, the necessary conditions for the successive ejections have been brought about by a somewhat complicated series of foldings, cross-foldings and faults, accompanied by an *elastic* crust of siliceous material. The subject is one which can be studied in these regions to great advantage, but we are only beginning to understand how simple is the problem which nature has solved with much variety of detail to suit changing conditions of environment.

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[1] The Geology and Vein-structure of Southwestern Colorado. By Theo. B. Comstock. Transactions Institute of Mining Engineers, Bethlehem meeting, May, 1886 (4 maps). Reprint, pp. 24–29, *et seq.*